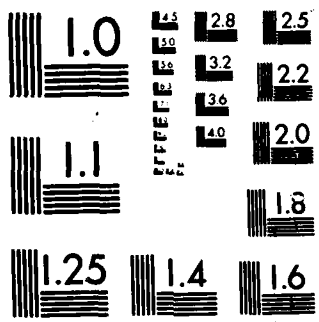
AD-A165 154 DEVELOPMENT OF A LOW NOISE 10K JT REFRIGERATION SYSTEM 1/1
(U) MMR TECHNOLOGIES INC MOUNTAIN VIEW CA FEB 86
N00014-85-C-0428

UNCLASSIFIED F/G 13/1 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Development of a Low Noise
10K J.T. Refrigeration System

Final Technical Report 0001AC

Contract No. N00014-85-C-0428

February 1986

MMR Technologies, Inc.

1400 Stierlin Road, #A-5
Mountain View, CA 94043

William A. Little
Chairman

ABSTRACT

The purpose of this Contract is the development of a Low Noise, Closed Cycle Joule-Thomson refrigeration system for 10K operation. This report summarizes work completed to date on the fabrication of the first two stages of the cooler. The argon stage has been tested and has been found to meet the cooldown time specification. Testing of the hydrogen stage will be done shortly. Design of the helium stage has been completed and the photomasks prepared. The hydraulically actuated, single gas compressor has been modified for higher pressure operation and has been tested. Satisfactory operation has been obtained and life testing is beginnning.

1.0 INTRODUCTION

This report summarizes the results of an engineering design program undertaken by MMR Technologies, Inc., for the Office of Naval Research under Contract No. N00014-85-C-0428. The purpose of this program is to develop a low noise, closed cycle, Joule-Thomson, microminiature refrigeration system for 10K operation.

During this period the effort has been focussed on the fabrication of the argon and hydrogen stages of the three stage cooler. A test facility was designed and built which allows one to mount each refrigerator on a separate removable base and to test each in turn. This is described in Section 2.1.

Key to the successful fabrication of the refrigerator is the determination of the proper firing profile for sealing the refrigerator components. Three batches of refrigerators have been built to date, and reasonable yields are now being obtained for the fabrication of these stages. The details of the firing profiles are reported in Section 2.2.

The helium stage has been designed and laid out, and the photomasks prepared. These are described in Section 2.3.

In Section 2.4 the results obtained to date with these refrigerators are summarized.

Work has continued on the hydraulically actuated compressor. Progress on this is reported in Section 3.

2.0 REFRIGERATOR FABRICATION AND TEST

In the early stages of the development of a new refrigerator it is usually necessary to test a large number of refrigerators to determine what refinements must be made in the design. To do this it is necessary to have a reuseable test facility to which each refrigerator can be bonded and after test, removed. Such a test facility has been designed and built for the test of the three stage cooler.

2.1 Test Facility

The design of the test facility was based on one used previously for the test of fast cooldown refrigerators for operation to 80K. This consisted of a vacuum chamber with feedthroughs for thermocouples, diode thermometers and resistance heaters, and a removable base flange for the refrigerator. The refrigerator mounting flange was modified to be made of stainless steel so that the seven gas lines to the refrigerator could be hydrogen brazed to the steel base rather than soft soldered. This gives a cleaner and more reliable bond than the soft soldered joints used

previously. Two, five gas-line bases were furnace brazed in a hydrogen atmosphere using pure copper as the brazing alloy. These were designed for use in testing the argon and hydrogen stages prior to the addition of the helium stage. An additional two, seven gas-line bases were also brazed by the same method for use with the complete cooler.

2.2 Refrigerator Fabrication

With the completion of the photomasks for the argon and hydrogen stages, fabrication was started on the component parts for these stages. This part of the refrigerator consists of five layers, however, to test this part without the final helium stage in place, a blank-off layer of glass is needed as a sixth layer. This was added to the stack.

To date three batches have been prepared in an effort to determine the best firing profile (time vs. temperature) in the furnace. Each batch consisted of four refrigerators.

Batch #1 - The firing profile used for fabricating the MMR standard product 80K refrigerator was used for this batch. Incomplete sealing of the layers occurred with several voids on some layers in each refrigerator. The refrigerators were refired using a longer ramp and high bake temperatures. The voids remained and no useable refrigerators were obtained.

Batch #2 - The longer ramp and higher bake temperature described above was used. Three refrigerators still had voids but one was sealed perfectly. The good one was used for initial tests of flow and cooldown time.

Batch #3 - A similar ramp and bake were used for #2. All samples were free of voids but two had channels collapsed in layer four containing the finest capillaries for the hydrogen stage. The other two were perfect. The reason for the difference between batches two and three is not known at present. Further examination of the refrigerators and data from the next batch should clear this up.

The present firing profile gives a sufficient number of refrigerators to refine the design for the depths of the channels. Later the profile can be optimized to improve the yield.

2.3 Helium Stage Design

The helium stage of the refrigerator has been designed. It was designed to make optimum use of the available heat exchanger surface area. This has been laid out, the rubylith cut and the photomasks prepared. In Figure 2.2, the step-and-repeat pattern of this layer is shown to scale, and in Figure 2.3 the detail of the step-and-repeat pattern for the final outflow channel. These parts will be fabricated as soon as tests on the argon and hydrogen stages are completed.

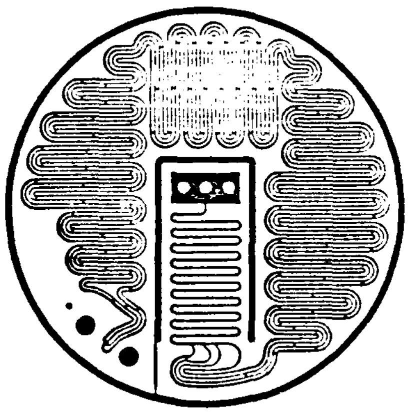


Figure 2.1 Enlarged view of inflow channels of helium stage. The 10K Cold stage is in the center at the dark reservoir at the end of the expansion capillary.

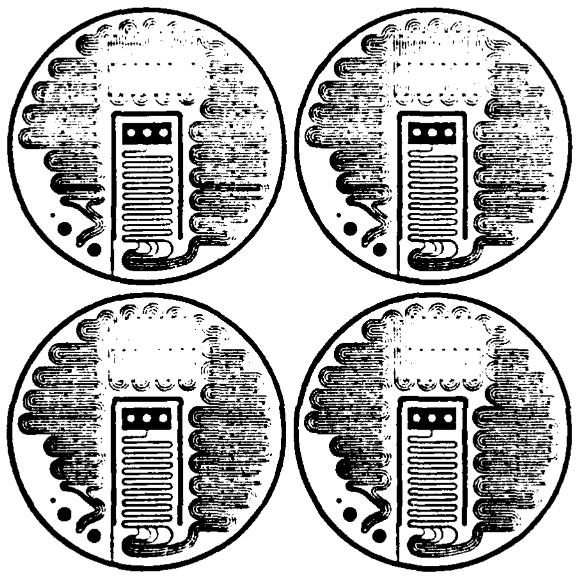


Figure 2.2 Step-and-Repeat pattern of helium inflow channels. Actual size.

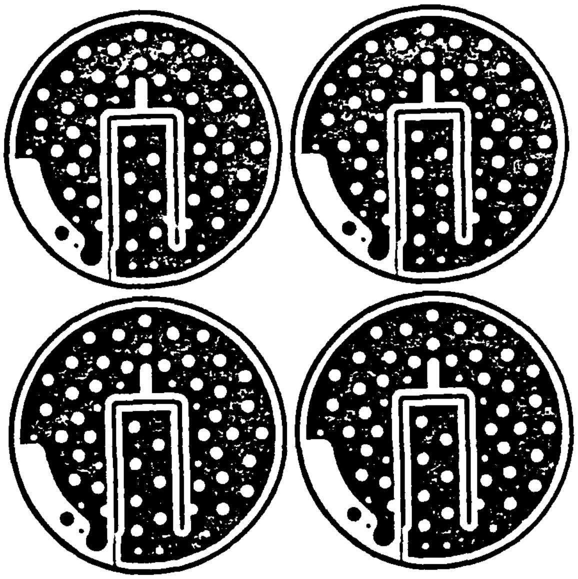


Figure 2.3 Laminar flow, low pressure helium stage outflow channel. Actual size.

2.4 Test Results

Refrigerator #006, the first successfully fired refrigerator from the second batch, was mounted on the test facility flange and tested for leaks. No leaks were detected.

A calibrated silicon diode thermometer was cemented to the top of the refrigerator immediately above the argon reservoir which is positioned at the 2.00 pm position in layer #2. This is shown in Figure 2.4. For these tests the top of the refrigerator was sealed with a blank-off layer of glass across the entire top surface. In addition, in order to give the refrigerator added strength during these initial tests, the thin slot between the hydrogen stage and the ambient temperature mounting point was not cut (see Figure 2.5).

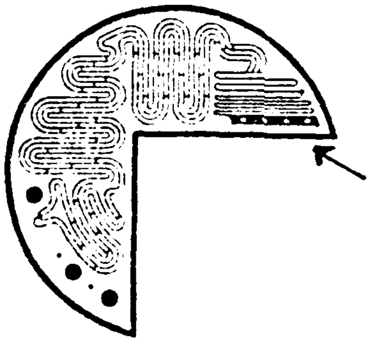
Measurements were then taken of the gas flow through the main argon heat exchanger ("short outflow") and the laminar flow, low pressure heat exchanger ("long outlfow") as a function of pressure.

Next, the refrigerator was allowed to cool and the time to reach a steady state measured. This was done using argon and then nitrogen gas at pressures up to 135 atm.

The flow through the two heat exchangers as a function of pressure, for argon is shown in Figure 2.6.

At 135 atm. input pressure, using argon, the refrigerator cooled to minimum temperature in 2.4 minutes. A second sample (#011) cooled in 2.0 minutes. The minimum temperature reached was 104K. This is higher than the design value and indicates a higher back pressure in the final boiler. Corrections for this will be made in the next iteration where a deeper long outflow channel will be used.

The two samples were damaged before the hydrogen stages could be measured. Two new samples are being mounted and will be tested shortly.



<u>Figure 2.4</u> **Layer** #2 showing location of argon reservoir.

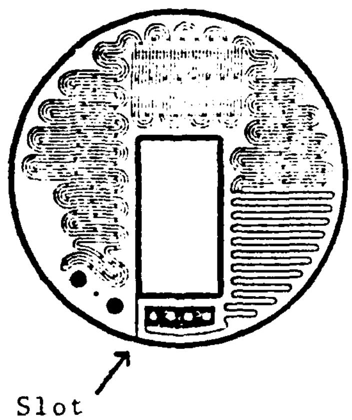


Figure 2.5 Location of slot separating hydrogen reservoir from ambient temperature mounting point.

ONR Refrigerator #006

Argon Flow Test

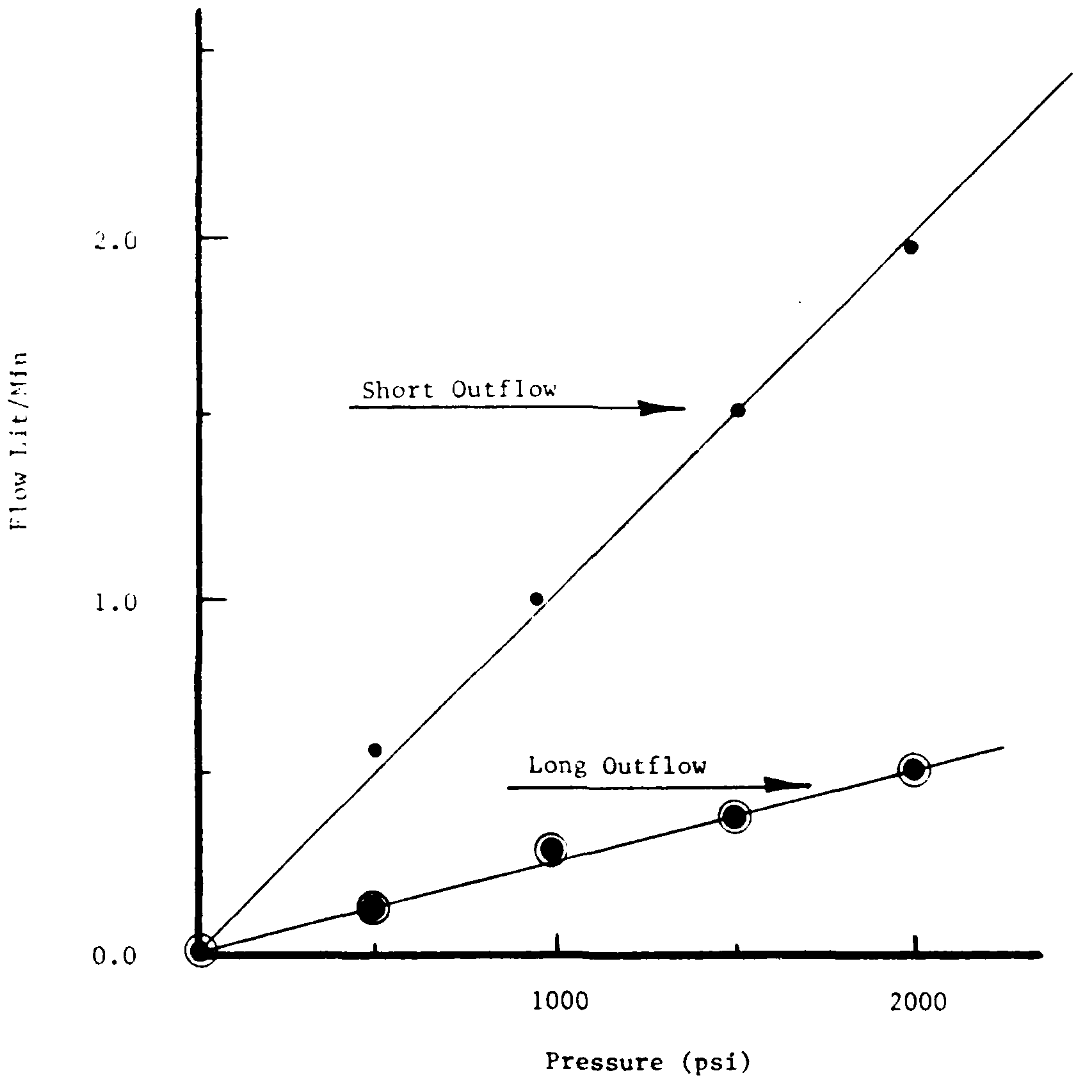


Figure 2.6 Flow vs. pressure data for Argon stage. Main heat exchanger (Short Outflow) and low pressure heat exchanger (Long Outflow).

3.0 COMPRESSOR DEVELOPMENT

As discussed in the previous report, the only major problem encountered in the first four hundred hours of operation of the first, single gas compressor, was the leakage of hydraulic fluid past the rod seals of the hydraulic compressor. The low pressure hydraulic cylinder has now been replaced with one rated for operation at 3,000 psi. In addition the end plates of both the low and high pressure cylinders have been redesigned and strengthened to provide a more secure mount for the valve assemblies.

The new unit has been tested. Some adjustments had to be made in the timing cycle to compensate for the difference in the volume of the new cylinder. When these were made it operated satisfactorily and provided 4.0 liters/minute at 2,000 psi. It is now being set up for continuous operation to determine the rate of wear of the seals.

4.0 OBJECTIVES OF THE NEXT REPORTING PERIOD

During the next reporting period it is expected that the following tasks will be completed or will be under way.

a) Test and characterization of the argon and hydrogen stages.

b) Fabrication of the helium stage.

c) Firing of the complete three stage cooler.

d) Initial measurements will be done on the complete cooler.

e) Long term testing of the single gas compressor will be under way.

f) The design work on the three gas compressor will be under way.

END

FILMED

4

DTIC